CS 290
Host-based Security and Malware

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Computer Forensics

Computer Forensics

- Goal
  - explain the current state of a digital artifact
- Process
  - collect and analyze digital evidence
- Digital evidence
  - in principle, physical traces (e.g., magnetic fields on hard drives)
  - abstraction: bits -> characters -> file blocks -> files -> mail
  - each abstraction step must be documented (to hold in court)
    but we focus here on the technical aspects
  - tons of digital traces everywhere
    - temporary files, logs, cache, backups, network packets, …

Forensics Process

- Seize evidence
- Preservation
  - ensure that evidence is not modified when analyzing
  - modifications can occur quickly (mount disk, boot computer)
- Recovery
  - obtain all data
  - hidden or deleted files
- Harvesting
  - obtain meta information about data
  - group by file type, access times, …

Forensics Process

- Reduction + Focus
  - filter irrelevant data
  - often, a huge problem due to data volume
  - hash database
    - NIST National Software Reference Library -- http://www.nsrl.nist.gov/
  - index data (like desktop search)

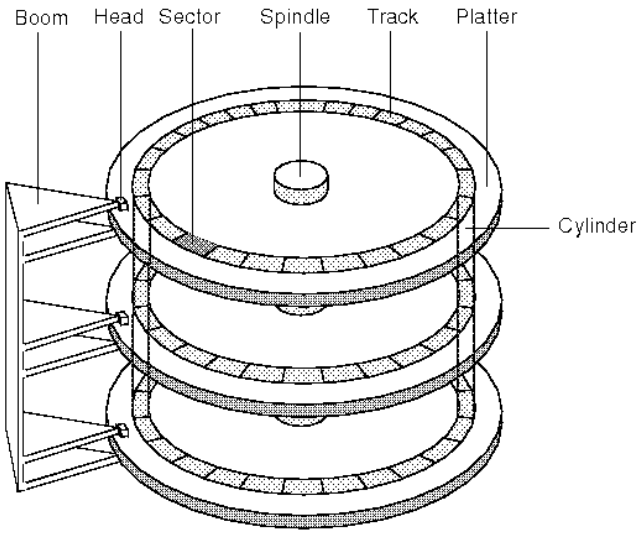
- Analysis and Reporting
  - scrutinize data to support hypothesis
  - write up (convincing) report

Disk Analysis

- Hard disks
  - still the most significant source of digital evidence
- Analysis process
  - save (preserve) disk content
  - disk and partition analysis
  - file system analysis

Disk Architecture

- Hard disk
  - several platters – disks (heads)
  - each platter has multiple tracks (start with 0)
  - each track has multiple sectors (start with 1)



Disk Architecture

Addressing sectors (blocks)

- CHS (cylinder, head, sector) triple
  - old disks use 10 bits for cylinder, 8 bits for head, 6 for sector
  - limits maximum disk size to ~ 8.4 GB

- Logical block address (LBA)
  - decouples logical and physical location
  - specifies 48 bit logical block numbers
  - allows controlled to mask corrupt blocks

Disk Architecture

Disk Interfaces

between controller (motherboard) and disk

- ATA (AT Attachment)
  - 28 bit addresses (~128 GB maximum size)
  - 40 pin cables, 16 bit parallel transfer (single-ended signaling)
  - 2 devices (master and slave) can be attached to connection cable
  - ATA-3 introduced security features (passwords)

- Serial ATA (SATA)
  - 8 pin cables
  - higher data transfer (differential signaling)

Disk Architecture

- Hidden protected area (HPA)
  - introduced with ATA-4
  - disk can be set to report to OS less blocks than actually available
  - remaining blocks can be used for data that is not formatted utilities and diagnostic tools, but also malicious code or illegal material
- Device configuration overlay (DCO)
  - introduced with ATA-6
  - additional space (blocks) after HPA
  - used by manufacturers to shrink different disks to appear with exactly the same size

Boot Process

- BIOS
  - firmware that holds starting code
  - performs system checks and loads MBR
- MBR (master boot record)
  - first block on hard disk (512 bytes)
  - structure
    - 446 bytes for code
    - 4 x 16 bytes for four partition table entries
    - 4 byte MBR signature (0xAA55)
  - chain loading of first block of bootable partition (OS loader)
- Interesting “return of the boot viruses”
  - Mebroot is a MBR virus that loads a stealth backdoor
  - patches Windows on-the-fly while it is loaded

Analysis – Save Content

- What to save
  - typically at the level of disk blocks (less often, file system objects)
- How to access disk
  - talk to controller (ATA commands)
  - use BIOS routines (int 0x13)
  - use OS routines (`dd` for Linux)
- Caveats
  - make sure that no writes are performed (write blocker)
  - expect and handle corrupt blocks

Analysis – Save Content

Analysis – Save Content

Image MASSter

RoadMASSter-3 Portable Forensic Lab

Portable Forensic Evidence Seizure Preview and Analysis System

- The RoadMASSter-3 Forensics System is designed as a high-speed Forensic Data Acquisition and Analysis tool.
- Ruggedised and built for the road, the unit provides for high-speed data seizures exceeding 3.5GB per minute.
- It supports today's common drive interfaces including P-ATA, S-ATA, SCSI and SAS drives, FireWire 1394A/B, USB1.0./2.0, Gigabit Ethernet and other solid state devices.
- While on location the Suspect's hard drive or the Evidence hard drive can be previewed under the Windows Operating System or analysed using third party data analysis software tools.
- Durability and performance makes this unit unique in the market place.

Analysis – Partition Analysis

- MBR stores partition table
- Partition table
  - describes layout of a drive (disk)
  - has four slots
  - define start and end sector of different partitions
- Partition
  - in Windows, partition maps to a drive – such as c:\
  - in Unix, partitions are mapped into a single tree – starts at /
  - what about sectors that are not part of any partition?

Analysis – Partition Analysis

- Extended partition
  - only four partitions possible (this is not enough)
  - solution – make one table entry pointer to an *extended partition*

- Extended partition
  - holds list of entries that point to more partitions
  - each entry stores size of partition and pointer to next entry
  - no limit (except disk space)

Analysis – Partition Analysis

```
chris@segfault: hexdump –v ext-part-test-2.dd
*****
0000190 0000 0000 0000 0000 0000 0000 0000 0000
00001a0 0000 0000 0000 0000 0000 0000 0000 0000
00001b0 0000 0000 0000 0000 fef4 8a8f 0000 0100
00001c0 0001 1f04 193f 003f 0000 cc81 0000 0000
00001d0 1a01 1f04 333f ccc0 0000 ccc0 0000 0000
00001e0 3401 1f04 4d3f 9980 0001 ccc0 0000 0000
00001f0 4e01 1f05 9a3f 6640 0002 5e60 0002 aa55
0000200 0000 0000 0000 0000 0000 0000 0000 0000
*****
```

status (0x80 = boot, 0x00 = non-boot)

partition type (0x04 = FAT 16)

# of sectors = 0x0000cc81 [52353]

LBA of first sector = 0x0000003f [63]

Analysis – Partition Analysis

```
chris@segfault: mmls ext-part-test-2.dd

DOS Partition Table
Offset Sector: 0
Units are in 512-byte sectors

     Slot    Start        End          Length       Description
00:  Meta    0000000000   0000000000   0000000001   Primary Table (#0)
01:  -----   0000000000   0000000062   0000000063   Unallocated
02:  00:00   0000000063   0000052415   0000052353   DOS FAT16 (0x04)
03:  00:01   0000052416   0000104831   0000052416   DOS FAT16 (0x04)
04:  00:02   0000104832   0000157247   0000052416   DOS FAT16 (0x04)
05:  Meta    0000157248   0000312479   0000155232   DOS Extended (0x05)
06:  Meta    0000157248   0000157248   0000000001   Extended Table (#1)
07:  -----   0000157248   0000157310   0000000063   Unallocated
.....
```

Analysis – File System

- File systems
  - come in many different flavors
  - in principle, OS independent
    - FAT can be read by Windows, Linux, ..
  - in some cases, certain OS has special behavior
    - Windows expects that FAT file system has correct magic values, Linux ignores that
- File system objects
  - layout information
  - file content
  - file meta-information (FAT entries, i-nodes)
    - name, size, last modification times, which blocks are used

Analysis – File System

- Layout information
  - located in first block(s)
  - determine type of file system and location of other data structures (i-node blocks, FAT tables)
  - corruption is difficult to compensate
- Volume slack
  - unused blocks after file system

Analysis – File System

```
chris@segfault: fsstat fat-img.dd
FILE SYSTEM INFORMATION
--------------------------------------------
File System Type: FAT16
OEM Name: mkdosfs
Volume ID: 0x3f441e25
Volume Label (Boot Sector):
Volume Label (Root Directory):
File System Type Label: FAT16
File System Layout (in sectors)
Total Range: 0 - 30719
* Reserved: 0 - 0
** Boot Sector: 0
* FAT 0: 1 - 119
* FAT 1: 120 - 238
* Data Area: 239 - 30719
** Root Directory: 239 - 270
** Cluster Area: 271 - 30719
```

Analysis – File System

- File content
  - stored in blocks
  - allocation is file system dependent
  - blocks are often scattered over file system (fragmentation)

- Content analysis
  - check individual blocks or search for keywords/regular expressions
  - content might be split over block boundary
  - slack space (unused space in last block of file)

- File carver
  - programs that scan blocks for characteristic header/footer information used by applications (e.g., scalpel)

Analysis – File System

- File metadata
  - useful to narrow down search
    - e.g., all files that were created after certain time
  - can be manipulated
  - metadata space can also be used to hide data

Analysis – File System

- File deletion
  - different file systems handle deletion differently
  - typically, only metadata is deleted
  - as a result, data content remains on disk

- Undelete
  - in FAT
    - only first character of directory entry is deleted
    - FAT table entries are freed
    - for non-fragmented files, undelete is quite easy
  - for other systems, often more difficult

Analysis – File System

Securely destroying / deleting data is difficult

Department of Defense Manual 5220.22 M

1. Degauss with a Type I degausser (degaussing exposes the drive to an electromagnetic field)
2. Degauss with a Type II degausser
3. Overwrite all addressable locations with a character, its complement, then a random character and verify. THIS METHOD IS NOT APPROVED FOR SANITIZING MEDIA THAT CONTAIN TOP SECRET INFORMATION.
4. Destroy –Disintegrate, incinerate, pulverize, shred or smelt.

Analysis – File System

May 31, 2005 3:02 PM PDT

Dumped hard drives tell all

Posted by Joris Evers

Font size Print E-mail Share Post a comment

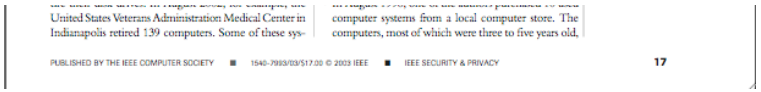
Sensitive corporate data just $10 on eBay

OUT-LAW News, 09/06/2004

Laptops and hard disks containing sensitive corporate data are readily available at auction sites. Researchers paid $10 for a hard disk from eBay which came with access codes to the secure intranet of one of Europe's largest financial services groups.

It was the first of 100 disks and laptops purchased as spare and used parts from internet auction sites as part of a study into the accessibility of information from lost laptops and hard disks.

In the study by security specialists Pointsec Mobile Technologies, seven out of ten of the disks, all of which were supposedly "wiped-clean" or "re-formatted," contained readable information.


United States Veterans Administration Medical Center in Indianapolis retired 139 computers. Some of these sys-

computer systems from a local computer store. The computers, most of which were three to five years old,

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Live System Analysis

- When system is running, additional information can be collected
  - active connections
  - active processes
  - loaded kernel modules
  - open files
  - clear text passwords (that are only resident in memory)
- Problems
  - analysis modifies state of system
  - rootkits (or other modifications) can tamper with results
- Memory dumps
  - take snapshot of memory of running system for later examination
  - can be done by software (/dev/kmem) or hardware extensions

Live System Analysis

- Physical (volatile) memory is also more persistent than one thinks
- Cold boot attacks